Money as a coordination device

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Abstract

This paper examplifies in a simple general equilibrium model the important role played by the monetary policy when there are strategic interactions bearing on nominal variables. It shows that the common notion of money neutrality is misleading in this context. Indeed, linear homogeneity in the money stock for all nominal variables does not imply that the money supply cannot affect real variables. Though in this case the money *stock* is neutral, the monetary *rule* (according to which money is supplied) alters strategic interactions. As a result, money can be used to resolve (weak) coordination failures.

1 Introduction

Imperfect competition is at the root of a large strand of recent macroeconomic literature (see Silvestre, 1993; Dixon and Rankin, 1994 and Benassy, 1995 for surveys). Because it gives rise to the so called "aggregate demand externality", imperfect competition can generate coordination failures. Two kinds of coordinating failures must be distinguished: the weak and the strong types[1]. Strong-coordination failure arises when there are several Pareto rankable non-cooperative equilibria and the prevailing equilibrium is not efficient. Weak-coordination failure arises when there is a single non-cooperative equilibrium which is Pareto dominated only by cooperative outcomes. These failures allow the existence of Pareto improving government policies. Strong-coordination problems are addressed by simply providing signals in order for non-cooperative agents to coordinate on a Pareto improving equilibrium while solving weak-coordination problems "requires changing the rules of the game" (Silvestre, 1993).

The literature stresses the fact that, for monetary policy to have real effects, either the neutrality principle must be invalid (e.g. in case of nominal rigidity) or there must exist strong-coordination failures (e.g. as in the "money as a sunspot" litterature). In other words, it is claimed that monetary policy is not an effective instrument for solving weak coordination problems in absence of any nominal rigidity. Indeed, it is argued that in presence of money neutrality, monetary policy is unable to produce any real effect.

The aim of the present paper is to show that this is not necessarily the case as soon as there are strategic interactions based upon nominal variables. In such a setting, the monetary rule according to which money is supplied *does* affect real variables. Though the money *stock* is neutral, in the sense that all nominal variables are homogeneous of degree 1 in the money stock, the monetary *rule* can affect the agents' strategic behavior by linking the money supply to strategic variables.

We present the simplest possible macro-model in which monetary policy can play such a role. We choose a two-sector model where the single market imperfection lies in the labor market where sectorial monopoly unions set nominal wages. The existence of sectorial interactions in the process of wage setting is a commonly admitted fact (see for instance Oswald, 1979 and Gylfason and Lindbeck, 1984). Other sources of market imperfection could have been added, but it would have obscured the exposition of the main mechanisms.

The paper is organized as follows. The next section presents the model and describes in turn the behavior of firms, consumers, unions and the monetary authorities. In the third section we compute the non-coordinated outcome. The fourth section describes in more detail the nominal strategic interactions. The fifth section presents the role of a coordinating monetary rule. Last section concludes.

[1]The present terms of weak and strong coordination failures are from Benassi et al., 1994. They correspond respectively to cooperation and coordination failure in Silvestre, 1993. We do not retain these latter terms because cooperation failure do not necessarily call for explicit cooperative behavior as such in order to be remedy.

2 The Model

We consider a two sector economy with competitive goods markets. The focus will be on sectorial strategic interactions. To this end, we introduce two monopoly unions, each setting the nominal wage on its segment of the labor market. For the sake of clarity, we use the simplest possible macroeconomic model displaying strategic interactions between both unions. Accordingly, we assume (i) Cobb-Douglas technologies and preferences; (ii) sectorial spillovers that are limited to the consumer price index spillover and to the usual macroeconomic budget constraints. A more complex framework would not change qualitatively our results.

2.1 Producers

There is a representative competitive firm in each sector with production function $Y_i = L_i^{\alpha}$, $0 < \alpha < 1$. Hence labor demand (L_i) and good supply (Y_i) functions are given by

$$L_i = \left(\frac{W_i}{\alpha P_i}\right)^{-\frac{1}{1-\alpha}}, \tag{1}$$

$$Y_i = \left(\frac{W_i}{\alpha P_i}\right)^{-\frac{\alpha}{1-\alpha}}, \quad i = \{1, 2\} \tag{2}$$

where W_i is the nominal wage prevailing in sector i.

2.2 Consumers

All workers have the same disutility of work (equals to v) and supply one unit of labor.. All consumers derive the same utility from consumption:

$$u_j = K_u \left(\frac{M}{Q}\right)^{1-c} \left(C_1^{\delta} C_2^{1-\delta}\right)^{c} - v h_j$$

with $h_j \in \{0, 1\}$: 1 if consumer j is working and 0 otherwise. $0 < c, \delta < 1$. C_1 and C_2 are two consumption goods, M is the nominal money holdings which can be derived as a mixed indirect utility function. K_u is a normalization constant used to alleviate further notations and is equal to $(1-c)^{c-1} c^{-c} \delta^{-\delta} (1-\delta)^{-(1-\delta)}$. Q is the true consumer price index given by:

$$Q = P_1^{\delta} P_2^{1-\delta}. \tag{3}$$

The aggregate nominal budget constraint is: $\Omega = M + Y$ where $Y = P_1 Y_1 + P_2 Y_2$ stands for nominal national product. The aggregate demands can be derived as:

$$\left\{ \begin{array}{c} M^d = (1-c)\Omega \\ C_1 P_1 = c\delta\Omega, \\ C_2 P_2 = c(1-\delta)\Omega. \end{array} \right. \tag{4}$$

As prices clear each goods market, total output is also equal to total consumption, i.e.:

$$\begin{aligned} Y &= P_1 C_1 + P_2 C_2 \\ &= c\Omega. \end{aligned}$$

Therefore, Ω and Y can be expressed as functions of money holdings:

$$\Omega = \frac{1}{1-c}M, \tag{5}$$

$$Y = \frac{c}{1-c}M. \tag{6}$$

2.3 Clearing prices

With our specification, market clearing prices are a weighed average of the nominal aggregated demand and of the nominal wage in each sector respectively. More formally, it is easily shown that:

$$P_1 = (c\delta\Omega)^{1-\alpha}\left(\frac{W_1}{\alpha}\right)^{\alpha} \tag{7}$$

$$P_2 = (c(1-\delta)\Omega)^{1-\alpha}\left(\frac{W_2}{\alpha}\right)^{\alpha} \tag{8}$$

2.4 Trade Unions

The labor market is segmented: The number of workers in each sector, and thus the supply of labor, is fixed and assumed to be larger than the demand for labor at all real wages larger than the marginal utility of leisure. All workers belonging to a particular sector are members of the corresponding sectorial trade union. The objective of union i is derived from the utilitarian aggregation over all union members' indirect utility level. Each union takes into account the real profits accruing to its members. We need a simple sharing rule for profits of both sectors. Assuming that all profits are distributed to workers[2], we can set the following sharing rule: members of union i receive the share γ_i of profits from sector i and the share $\left(1-\gamma_j\right)$ from sector j. It is given by:

$$\Psi_i = L_i\left(\frac{W_i}{Q} - v\right) + \gamma_i\frac{\Pi_i}{Q} + (1-\gamma_j)\frac{\Pi_j}{Q}, \quad i \neq j \in \{1,2\}. \tag{9}$$

In order to simply the analysis of the results, we assume that $\gamma_i = 1$ for both i. Hence there is no spill-over created by the profit distribution. However, this assumption does not alter qualitatively the results of the paper.

Because of the Cobb-Douglas production function, sectorial profit and labor shares are constant so that real sectorial profits can be expressed as

$$\frac{\Pi_i}{Q} = \frac{1-\alpha}{\alpha}\frac{W_i}{Q}L_i.$$

Inserting this relation in the union objective function (9) leads to the following simplification:

$$\Psi_i = \frac{L_i}{\alpha}\frac{W_i}{Q} - vL_i\ , \quad i \in \{1,2\}.$$

[2] Assuming that some share of the profit accrues to a person of private means does not alter the general results of the paper. For instance if one capitalist (and non-worker) receives all profits, each union i maximizes its objective with $\gamma_i = 0$ and $\gamma_j = 1$.

Simply, since profits also accrue to workers, the actual remuneration of one unit of labor is not W_i but $\frac{W_i}{\alpha}$.

Each union maximizes its objective for a given *nominal* wage for the other union. All other variables enter the maximization. In particular, the effect of a nominal wage variation on the price index is taken into account by both unions. This assumption is reasonable as each sector is large enough to affect noticeably the price index[3].

The maximization of the union objectives implies that the real consumption wage is a constant mark-up on the outside option, equal here to the marginal disutility of work v. This mark-up is determined by the elasticities of the two objectives pursued by the union (namely, real wage and employment) with respect to nominal wage:

$$\frac{W_i}{\alpha} = \left[1 + \frac{\epsilon[W_i/Q, W_i]}{\epsilon[L_i, W_i]}\right]^{-1} vQ.$$

Each of these two elasticities can be decomposed so as to distinguish real and nominal variables:

$$W_i = \left[1 + \frac{1 - \epsilon[Q, W_i]}{\epsilon[L_i, \frac{W_i}{P_i}]\,(1 - \epsilon\,[P_i, W_i])}\right]^{-1} \alpha v Q. \tag{10}$$

The nominal wage is indexed on the consumer price. This link is the root of the strategic interactions. As will be seen later on, with the chosen specifications, all elasticities entering equation (10) will be constant. This allows great simplification of the analysis, but any more complex framework displaying sectorial interactions would have been suitable too. The precise value of these elasticities depends on the strategic behaviors of the unions (see section 3).

2.5 Monetary Policy

The money supply links the nominal quantity of money to the nominal wage levels. Let us assume that it is determined by the following general rule:

$$M = D^{1-\mu_1-\mu_2}\; W_1^{\mu_1} W_2^{\mu_2} \tag{11}$$

The present monetary rule is ad hoc and serves exclusively the point of showing that the choice of its parameters has real consequences. The paper does not address the question of the optimal policy rule. The present formulation implies that the money supply is adjusted automatically to changes in nominal wage levels. But any other formulations for the monetary rule linking the money supply to a nominal variable would have been suitable. What matters is that money supply may be *in fine* linked to at least one strategic nominal variable of the model.

At this stage, μ_1 and μ_2 can take any (positive or negative) value. The larger the value of μ_i, the more accommodating the monetary policy. We introduce the exogenous factor D to allow for discretionary change in the money supply. The exponent of D is meaningless since D is fully exogenous[4].

[3] However it is not crucial. What really matters instead is the assumption of common knowledge about the monetary rule described in next sextion.

[4] It simply implies that all nominal variables will be linearly homogeneous in D which avoids misleading interpretation on the role this parameter plays in the model. However, it is by no mean required for money neutrality.

The present formulation includes, as special cases, the simple monetarist rule where the money supply is kept constant ($D = \overline{D}$ and $\mu_1 = \mu_2 = 0$) and any formulation linking the quantity of money to the price index Q, e.g. $M = D\ Q^{\mu}$ (if $\frac{\mu_1}{\mu_2} = \frac{\delta}{(1-\delta)}$).

We assume the monetary rule to be common knowledge and credible. In particular, both sectorial unions take the central bank's behavior into account when setting their nominal wages.

The fact that the monetary authorities let the money supply depend on nominal variables is not surprising. Letting know that a wage increase in one of the sectors will trigger a restrictive (or a least a non-accommodating) monetary policy may dissuade the unions in this sector to have important wage claims. A good example of that is the timing of announcements by the German central bank when the largest trade union (IG-Metal) bargains over its future nominal wage increases. As this sector plays a leading role in wage formation, the monetary authorities have a strong incentive to link a restrictive monetary policy to this sector's wage level and to render this policy public.

The German central bank often refers to the orthodox monetarist theory to justify her decisions. It seems however very difficult to explain on this ground why a central bank should behave by *reacting* to wage claims. Accordingly, there should be no need for such "activist" policy: determining once and for all the money stock should be the most adequate policy. As will be shown, the present paper provides a possible explanation for the superiority of an "activist" money supply as the one proposed in eq.(11).

3 Non coordinated outcome

In order to determine the real wages set by unions in both sectors we need to determine the value of the three elasticities entering eq.(10). The elasticity of labor demand with respect to the real wage is given by the production function relation and is independent of the money supply:

$$\epsilon[L_i, \frac{W_i}{P_i}] = \frac{-1}{1-\alpha}.$$

The second elasticity relates the output price to the nominal wage level. Using the equation of money supply (eq.(11)) to eliminate financial wealth Ω in the price equations (7) and (8), one gets:

$$P_1 = \alpha^{-\alpha} \left(\frac{c\delta D^{1-\mu_1-\mu_2}}{1-c} \right)^{1-\alpha} W_1^{\alpha+(1-\alpha)\mu_1} W_2^{(1-\alpha)\mu_2} \quad (12)$$

$$P_2 = \alpha^{-\alpha} \left(\frac{c(1-\delta) D^{1-\mu_1-\mu_2}}{1-c} \right)^{1-\alpha} W_1^{(1-\alpha)\mu_1} W_2^{\alpha+(1-\alpha)\mu_2}. \quad (13)$$

These equations show that the ability of unions to pass a nominal wage increase onto the price of output depends on the monetary rule. This ability is crucial since it determines the elasticity of labor demand with respect to a nominal wage variation[5]. Therefore, the monetary policy can

[5] Inserting eq.(12) and (13) in the labour demand for sector 1 and 2 respectively, gives:

$$L_1 = \frac{\alpha c \delta}{1-c} D\ W_1^{-1+\mu_1} W_2^{\mu_2} \quad (14)$$

weaken or tighten the labor demand constraint perceived by a union when it sets its nominal wage.

The third elasticity relates the price index to the nominal wage level. Expressing the price index as a function of the money supply and the nominal wages (by inserting eq. (12) and (13) in eq.(3)) leads to[6]:

$$Q = K_Q \; D^{(1-\alpha)(1-\mu_1-\mu_2)} W_1^{\alpha\delta+(1-\alpha)\mu_1} W_2^{\alpha(1-\delta)+(1-\alpha)\mu_2}. \tag{16}$$

The effect of a nominal wage rise on Q can be decomposed into two parts: the first one comes through the direct price increase following the wage rise and does not rely on a coordinating monetary rule. This effect obviously depends on the sectorial share in national demand (i.e. δ or $(1-\delta)$). The second effect arises because of the link between the nominal wage and the money supply. The looser a monetary rule is (that is, the larger μ_i is), the larger the effect of a nominal wage increase on the price index is.

Table 1 summarizes the different elasticities needed to compute real wages.

Table 1

	L_1	Q	L_2
W_1	$-1+\mu_1$	$\alpha\delta + (1-\alpha)\,\mu_1$	μ_1
W_2	μ_2	$\alpha(1-\delta) + (1-\alpha)\,\mu_2$	$-1+\mu_2$

Introducing the different elasticities shown in table 1 in the real wage equation (10) gives the following non-coordinated real wages (R^{nc})[7]:

$$R_1^{nc} = \frac{W_1}{Q} = v \; \frac{1-\mu_1}{\delta-\mu_1} \tag{17}$$

$$R_2^{nc} = \frac{W_2}{Q} = v \frac{1-\mu_2}{1-\delta-\mu_2}. \tag{18}$$

Equations (17) and (18) show clearly that the monetary rule affects *real* wages. Propositions 1 and 2 summarize this result.

Proposition 1 *In the present model, money is "neutral" in the sense that all nominal variables are linearly homogeneous in M.*

$$L_2 = \frac{\alpha c(1-\delta)}{1-c} D \; W_1^{\mu_1} W_2^{-1+\mu_2}. \tag{15}$$

Without a coordinating monetary rule ($\mu_1 = \mu_2 = 0$), the elasticity of labour demand is simply equal to -1, labour demand in one sector is not affected by the level of wages in the other sector.

[6]With $K_Q = \alpha^{-\alpha}\left(\frac{c}{1-c}\delta^{\delta}\,(1-\delta)^{1-\delta}\right)^{1-\alpha}$.

[7]In order to get real wages larger than ν, we impose $\mu_1 < \delta$ and $\mu_2 < (1-\delta)$. We could also accept values of $\mu_1 > \frac{1-\alpha\delta}{1-\alpha}$ and $\mu_2 > \frac{1-\alpha(1-\delta)}{1-\alpha}$ but this would imply that a nominal wage increase yields a reduction in consumer wage wich seems paradoxical. This also implies that all nominal variables are homogeneous of degree $k < 0$, i.e. an increase in D implies a fall in all nominal variables! The limiting case $\mu_1 = \delta$ and $\mu_2 = (1-\delta)$ that implies $\frac{M}{Q} = D$, i.e. a constant real money stock wich means that there is no deflationary effect on nominal aggregate demand when W increases. Hence, there is no restraining force on a nominal wage increase and the slope of the reaction function is equal to 1. For larger values of μ_1 and μ_2,either the Nash equilibrium does not necessarily exist or it leads to negative consumer wages.

Proof. The nominal variables $(P_1, P_2, Q, \Omega, W_1, W_2)$ are defined by six log-linear equations in function of the real wages (R_1, R_2) given by eq. (17) and (18) and the money supply M:

$$\left\{\begin{array}{c} p_1 = \alpha w_1 - \alpha \ln \alpha + (1-\alpha)(\ln c + \ln \delta + \ln \Omega) \\ p_2 = \alpha w_2 - \alpha \ln \alpha + (1-\alpha)(\ln c + \ln(1-\delta) + \ln \Omega) \\ q = \delta\ p_1 + (1-\delta)\ p_2 \\ \ln \Omega = \ln M - \ln[1-c] \\ w_1 = r_1 + q \\ w_2 = r_2 + q \end{array}\right.$$

Clearly, all nominal variables are linearly homogeneous in the money supply M. This implies that relative prices and real variables are independent of M. ■

The fact that the money supply can be decomposed in two parts (a discretionary one ΔD) and an endogenous one linked to nominal variables does not prevent money neutrality.

Proposition 2 *Though money is neutral, the monetary* rule *affects real variables provided that (i) the money supply is linked to strategic variables and (ii) the strategic interactions are based upon nominal variables, i.e. each agent takes the other agent's nominal wage as given.*

The distinction between a discretionary and an endogenous part in the money supply is crucial since a *discretionary* change in the money supply (ΔD) has no real effect though a change in the monetary *rule* $(\Delta \mu_i)$ have real consequences.

This has major implications for monetary policy combining monetarist and activist features. First, the quantity of money only determines the price level. Second, an endogenous money supply is able to affect real variables in the long run even in absence of any nominal rigidity. Third, this is possible if money is supplied according to a well defined rule which is common knowledge. The first and third features obviously refer to standard monetarist approach while the second feature gives credit to the activist approach.

This is possible as all strategic interactions rely on nominal variables: each agent reasons at a given nominal wage for the other sector. As a consequence, each union behaves as if it had the opportunity to transfer the cost of a nominal wage increase onto the other sector's consumers. Since the monetary rule is able to manipulate this opportunity, it can influence the strategic interaction between unions. This observation leads to the following corollary.

Corollary 1 *If both sectors set their wage for a given* real *wage in the other sector, the monetary rule would become ineffective.*

Proof. In this case, all nominal interactions disappear: each union incorporates the other union's nominal reaction, and the perceived opportunity to transfer the cost of a wage increase vanishes. Each union makes use of the one for one relation between the price index and the nominal wage for the other sector. That leads to the following consumer wages[8]:

$$\begin{aligned} R_1^{index} &= \frac{v}{\delta}[1-\alpha(1-\delta)] \\ R_2^{index} &= \frac{v}{1-\delta}[1-\alpha\delta]. \end{aligned}$$

[8] We call them "index" for indexation for reasons that will be clarified in the next proposition.

These real wages do not depend on the monetary rule parameters. ■

A simple way to insure that both unions take into account the repercussion on the nominal wage of the other sector, is to impose an automatic (full) indexation clause.

Proposition 3 *Automatic indexation removes any role to a monetary rule.*

In the absence of an automatic full indexation clause, it seems unlikely that *both* unions behave according to real variables. The argument goes as follows. A union reasoning at a given real wage for the other union is simply taking the actual reaction of the other into account. In this sense, she simply behaves as a Stackelberg leader. However, both agents cannot be leader simultaneously[9]! On the contrary, automatic indexation allows all agents (whatever their number) to reason in terms of real wages: they need not incorporate the nominal consequences of their action when setting their nominal wage.

We now focus on the nominal strategic interactions in order to understand the mechanisms by which the monetary rule operates.

4 Money as a coordination device

We can resort to the centralized outcome as a point of comparison in order to conclude on what direction to move both μ_i. An optimal real wage level would require that all sectorial spillovers affecting unions are fully internalized. In the presence of a negative global spillover, coordination should yield smaller nominal and real wages. More precisely, the first order condition for Pareto efficient outcomes defines a locus where indifference curves of both unions are tangent. It can be shown that this locus corresponds to:

$$v = \delta R_1 + (1-\delta) R_2.$$

Since the union objective functions are not defined for $R_i < v$, the only possible coordinated outcome is the competitive one ($R_1 = R_2 = v$). This is also the real wage level attained by a centralized wage setting when unions jointly maximize the sum of their utilities ($\Psi_1 + \Psi_2$). Obviously, it leads to the maximum national welfare which is simply defined as:

$$\Phi = \frac{\Omega}{Q} - v\left(L_1 + L_2\right).$$

Φ is a function of both real wages[10].

[9] In the sense that both players playing the Stackelberg leader's strategy is not a Nash equilibrium. Simple ways out to this problem are the game repetition or a dynamyc setting allowing for staggered wage setting.

[10]

$$L_1 = \alpha^{\frac{\alpha}{1-\alpha}} \left(\frac{\delta}{1-\delta}\right)^{1-\delta} R_1^{-1-\frac{\alpha\delta}{1-\alpha}} R_2^{-\frac{\alpha(1-\delta)}{1-\alpha}} \quad (19)$$

$$L_2 = \alpha^{\frac{\alpha}{1-\alpha}} \left(\frac{\delta}{1-\delta}\right)^{-\delta} R_1^{-\frac{\alpha\delta}{1-\alpha}} R_2^{-\frac{1-\alpha\delta}{1-\alpha}} \quad (20)$$

$$\frac{\Omega}{Q} = \alpha^{\frac{\alpha}{1-\alpha}} \left(\delta^{\delta}(1-\delta)^{1-\delta}\right)^{-1} \left(R_1^{\delta} R_2^{1-\delta}\right)^{\frac{-\alpha}{1-\alpha}} \quad (21)$$

Any reduction in one or both real wages (towards the competitive level v) improves welfare and reduces the lack of coordination. Intuitively, as long as both real wages are higher than their competitive value (equal to v), a reduction in one of them is bound to lead the economy closer to its maximum welfare level. Indeed, as long as the utility gain brought about by additional production is smaller than the disutility of labor needed to produce it, reduction in real wages implies welfare improvement.

As already observed in eq.(17) and (18), consumer wage R_i is a monotonically increasing function of μ_i inside the relevant interval[11]. Hence the monetary rule must be restrictive in order to reduce the lack of coordination. This happens through a reduction in the strategic complementarity for both unions.

Proposition 4 *By reducing the strategic complementarity between sectorial wages, a restrictive monetary rule reduces the lack of coordination.*

Proof. Because the global sectorial spillover never vanishes (see appendix 1), the non-coordinated outcome is always sub-optimal for any value of μ_i and yields too large nominal (and real[12]) wages. The consequences of this lack of coordination are worsened when there is strategic complementarity between union's nominal wages.

Since both union 's objective boils down to keeping its consumer wage constant, the price index equation (16) determines the reaction function of each union. The reaction functions are log-linear and their slope is given by

$$\rho_i = \frac{d\log W_i^*}{d\log W_j} = \frac{\epsilon[Q, W_j]}{1 - \epsilon[Q, W_i]}.$$

The whole reaction functions are given by

$$w_1 = \frac{r_1 + k_Q + (1-\alpha)(1-\mu_1-\mu_2)d + [\alpha(1-\delta) + (1-\alpha)\mu_2]\, w_2}{1 - \alpha\delta - (1-\alpha)\mu_1}, \tag{22}$$

$$w_2 = \frac{r_2 + k_Q + (1-\alpha)(1-\mu_1-\mu_2)d + [\alpha\delta + (1-\alpha)\mu_1]\, w_1}{1 - \alpha(1-\delta) - (1-\alpha)\mu_2}. \tag{23}$$

Small letters denote the log of variables in capitals.

Since both ρ_i depends on both μ_i, a monetary rule can perfectly adjust the level of strategic complementarity or substitutability for each unions' wage. In order to reduce both ρ_i (to -1), it is necessary to let both μ_i fall (towards $-\infty$). ■

For this reason, in the present context, a restrictive money supply (i.e. $(\mu_1, \mu_2) < (0, 0)$) can be called a "*coordinating monetary rule*". For instance, it is possible to suppress all strategic interactions by setting $\mu_1 = -\frac{\alpha\delta}{(1-\alpha)}$ and $\mu_2 = -\frac{\alpha(1-\delta)}{(1-\alpha)}$. In this case, a wage variation in one sector does not affect the price index level (see eq.(16)). This solution allows to replicate the outcome with automatic indexation. In this case the real wages are smaller than with a non-coordinating monetary rule ($\mu_1 = \mu_2 = 0$) (see proof of corollary 1).

[11] The intervals that lead to positive real wages are given by $]-\infty, \delta]$ for μ_1 and $]-\infty, 1-\delta]$ for μ_2.

[12] Higher nominal wages mean higher real consumer wages as the elasticity of Q to W_i is always smaller than 1 when μ_i is assumed smaller than δ for $i = 1$ and $(1-\delta)$ for $i = 2$.

Proposition 5 *Automatic indexation is a coordination device since it suppresses strategic complementarity between union's wages and thus prevents a wage overbidding between sectors in absence of any coordinating monetary rule.*

Proposition 6 *There exists a restrictive monetary rule which replicates the coordination taking place with an automatic indexation clause.*

This monetary rule cancels the effect of both nominal wages on the price index through a reduction in the money supply (and thus aggregate demand) exactly balancing the effect of the wage increase on the output supply curve.

A more restrictive monetary rule than the one just described would lead to strategic *substitutability* for one or both unions' wage and would further improve national welfare. With automatic indexation, the coordination problem is less acute but money can no longer be used as a coordination device. Therefore whether automatic indexation should be implemented or not depends on the ability of the monetary authorities to follow a more restrictive monetary policy. Though the aim of the paper is not to find the optimal monetary rule, the rest of this section investigates the possibility of a monetary coordination inside the class of monetary rules defined by eq.(11).

Ideally, in order to reduce R_i to v, both μ_i must fall towards minus infinity. Therefore, this outcome cannot be reached through a coordinating monetary rule[13]. This extreme case corresponds to both reaction functions being confound with a slope of -1. This means that there is an infinity of Nash equilibria and all nominal variables are undetermined[14]. In general, an optimal monetary rule will not be as extreme as it is here ($\mu_1 = \mu_2 = -\infty$) for several reasons. First, nothing precludes that the monetary rule be able to suppress the sectorial spillover instead of acting only on agents' strategic behavior. Second, labour supply may become inelastic for high employment levels. In this case, full employment may be reach at a higher real wage than the reservation wage v. As a result, a *finite* optimal monetary rule may exist.

From a practical stand-point, an infinitely restrictive monetary rule is probably not relevant. Obviously there are costs associated with the choice of a negative μ_i by the monetary authorities that are not taken into account in the present long term model. They can be caused by (e.g.) nominal price rigidity or sluggish price adjustments. Here, there is no nominal rigidity at all and reducing dramatically the money stock has no real effect (at least if this happens on a discretionary base ($\triangle D$)). It should however be kept in mind that, because of price rigidity, there are costs associated with a reduction in the money supply, wether that occurs through a discretionary change ($\triangle D$) or a planed one (μ_i). Hence, there could be some lower bounds to the values of the μ_i in our setting. For instance, one could imagine that $\frac{-\alpha}{1-\alpha}$ constitutes a lower bound for both μ_i as it implies that a nominal wage variation in one sector yields no price repercussion in this particular sector ($\epsilon[P_i, W_i] = 0$)[15].

[13] However there exist two trivial degenerated cases for $\delta = 0$ and $\delta = 1$ for wich there is only one sector in the economy. Hence there is no coordination problem and the optimal wage level is attained without coordination.

[14] In fact, since money is the root of the nominal strategic interaction, this solution limits the bad consequences of the nominal strategic interaction by suppressing the role for money!

[15] However, in this case, a wage change has an agregate deflationary effect on the price index ($\epsilon[Q, W_i] < 0$). Hence, one could think of a less restrictive policy as a lower bound. For instance, the condition that the price

Moreover a large share of possible coordination gains is obtained by setting both $\mu_i = \frac{-\alpha}{1-\alpha}$. We can use the cooperative outcome as a point of comparison. The maximum gain of coordination is the welfare gap between the non-coordinated outcome without any active monetary rule (Φ°) on the one hand, and a centralized wage setting on the other hand (Φ^{max}). We compute the coordination gains of a coordinating rule relatively to the maximum possible gain of coordination. That is, we compute the following ratio:

$$\frac{\Phi\left[\mu \neq 0\right] - \Phi^{\circ}}{\Phi^{max} - \Phi^{\circ}}.$$

Fig.1 displays three graphics, each for a different value of α (0.2, 0.5, 0.9). Each graphic shows the ratio of the welfare gain relatively to maximum welfare gains for three values of δ (0.5,0.75, 0.9) and $\mu_1 = \mu_2 = \mu$ when μ varies between 0 and $\frac{-\alpha}{1-\alpha}$. Values of δ smaller than 1/2 leads to identical relations. The effectiveness of a monetary rule falls as it becomes more restrictive (i.e. as μ falls). As a result, there is generally little to gain to reduce μ beyond $\frac{-\alpha}{1-\alpha}$, except for very small α[16]. Therefore the need for very deflationary monetary rules is limited.

Figure 1: Proportion in maximum coordination gain obtained by a symmetrical monetary rule.

5 Conclusion

This paper highlights the important role devoted to monetary policy when there are strategic interactions bearing on nominal variables. The neutrality principle does not incapacitate monetary policy, which can be used as a coordination device improving the outcome of the non-cooperative interaction. Therefore, imperfect competition is sufficient to lead to a real role for money as long as it gives rise to strategic interactions based upon nominal variables.

Though we have focused on a very simple static model where the single market imperfection lies in the labor markets, any framework incorporating nominal strategic interactions is likely to open the door to a coordination role for monetary policy. For instance, the source of market imperfection may lie on the output markets. An interesting extension could combine nominal rigidities and a coordinating monetary rule in a dynamic set-up in order to explicit the trade-off between the strategic coordination benefits of a money rule (requiring a restrictive money supply) and the cost of deflation associated with it.

index be independant of a general wage increase is rendered by the condition $\mu_1 + \mu_2 = \frac{-\alpha}{1-\alpha}$. In that case, an increase in a single wage will provoke a price index inflation if its corresponding μ_i represents a smaller share in the sum than its sectorial share.

[16] But this case is not very relevant as it corresponds to small sectorial spillovers (see eq.24). For $\alpha \rightarrow 0$, a wage variation entails no price modification and the sectorial spillover disapears. Then, a coordinating monetary rule becomes counterproductive.

It should be stressed that the monetary rule mechanism presented here does not display any "keynesian" effect *per se*. Despite the fact that money supply determines the nominal aggregate demand, the monetary rule is able to affect real variables only because it alters the market power of wage setting agents. In this sense, monetary policy affects the real state of the economy through a "classical mechanism" (see Grandmont, 1989 for a discussion). Moreover, a monetary rule must be "restrictive" in order to reduce agents' mark-up and expand real product.

From a terminological point of view, the paper stresses the fact that the usual definition of money neutrality in terms of linear homogeneity in the money stock for all nominal variables is misleading in a strategic context. It shows that the notion of money neutrality is misleading in this context. Indeed, linear homogeneity in the money stock for all nominal variables does not imply that the monetary rule cannot affect real variables. Hence, neutrality of the money *stock* must be distinguished from the possible non neutrality of the monetary *rule*.

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A Negativity of the global spillover

The global sectorial spillover consists of the labor demand spillover (eq.(14) and (15)) and of the price index spillover (eq.(16)). Though it is possible to find particular values for both μ_i that cancel each spillover in turn, it is not possible to suppress both spillovers simultaneously[17] or even to find a particular value for (μ_1, μ_2) that cancels the *global* spillover. We can compute the sectorial spillover at the non-cooperative equilibrium by the elasticity of e.g. Ψ_1 to a change in W_2 :

$$\phi_1 = \epsilon\left[\Psi_1, W_2\right] = \frac{-\alpha\left(1-\delta\right)\left(1-\mu_1-\mu_2\right)}{1-\alpha\delta-\mu_1\left(1-\alpha\right)}. \tag{24}$$

Since by assumption the numerator is always negative, ϕ_1 is a monotonic function of μ_1. The values of $\epsilon\left[\Psi_1, W_2\right]$ range from $-\frac{\alpha(1-\delta)}{1-\alpha}$ for $\mu_1 \to -\infty$ to $-\alpha\left(1-\delta-\mu_2\right)$ for $\mu_1 \to \delta$. Since the two bounds are always negative, the sign of the *global* sectorial spillover is always negative for any value of μ_1 or μ_2. The latter bound is larger than the former (i.e. $\epsilon\left[\Psi_1, W_2\right]$ is an increasing function of μ_1) if $\mu_2 > -\frac{\alpha(1-\delta)}{1-\alpha}$. On the contrary, ϕ_1 is always a positive function of μ_2. The same relations holds symmetrically for ϕ_2. Note that in order to minimize both ϕ_i simultaneously, the monetary rule must tend towards $\mu_1 = \delta$ and $\mu_2 = 1-\delta$.

B Stability of the Nash Equilibrium

A necessary and sufficient condition to have stability of the Nash equilibrium to a change in the discretionary money supply D (implying a change in the intercept of the reaction functions) is

$$\text{abs}\left[\rho_1\rho_2\right] < 1 \tag{25}$$

with

$$\rho_i = \frac{\epsilon\left[Q, W_j\right]}{1-\epsilon\left[Q, W_i\right]}.$$

We want to show that imposing

$$\begin{cases} \mu_1 < \delta \\ \mu_2 < 1-\delta \end{cases} \tag{26}$$

is a simple and sufficient condition to get stability.

First note that this latter condition implies that both $\epsilon\left[Q, W_i\right] < 1$. This last inequality implies that $\epsilon\left[W_i/Q, W_i\right] > 0$ so that a union must increase its *nominal* wage in order to increase its *consumption* wage which seems to fit observation. Therefore eq.(25) can be written as:

$$\text{abs}\left[\epsilon_1\epsilon_2\right] < 1-\epsilon_1-\epsilon_2+\epsilon_1\epsilon_2. \tag{27}$$

Two cases must be distinguished according to the sign of $\epsilon_1\epsilon_2$.

- If $\epsilon_1\epsilon_2 \geqslant 0$, eq.(27) is equivalent to:

$$\epsilon_1+\epsilon_2 < 1 \tag{28}$$

[17] Suppressing the spill-over occurring through labour demand (eq.(14) and (15)) requires both $\mu_i = 0$. But suppressing the price index spillover (eq.(16)) requires negative values for $\mu_1 = -\frac{\alpha\delta}{1-\alpha}$ and $\mu_2 = -\frac{\alpha(1-\delta)}{1-\alpha}$.

which is also equivalent to

$$\mu_1 + \mu_2 < 1. \tag{29}$$

And this last inequality is necessarily verified once the assumption (26) has be made, stability is always verified. The economic interpretation of this condition is straightforward. A similar increase in both nominal wages must induce less than a proportional price index rise.

- If $\epsilon_1\epsilon_2 < 0$,eq.(27) leads to:

$$0 < -2\epsilon_1\epsilon_2 < 1 - \epsilon_1 - \epsilon_2 \tag{30}$$

which is obviously a more demanding condition than eq.(29). As

$$\begin{aligned} \epsilon_1 &= \alpha\delta + (1-\alpha)\mu_1 \\ \epsilon_2 &= \alpha(1-\delta) + (1-\alpha)\mu_2, \end{aligned}$$

eq.(30) implies a cross constraint linking the values of $(\alpha, \delta, \mu_1, \mu_2)$. A thorough investigation of the stability condition is beyond the scope of the present paper. We simply assume the stability condition (30) fulfilled.